

## AVAILABLE COAL RESOURCES OF THE WISE 7.5-MINUTE QUADRANGLE, VIRGINIA

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### INTRODUCTION

In an attempt to more realistically define the amount of coal available for mining, coal availability studies have been completed for three 7.5-minute quadrangles and a study is currently underway for a fourth quadrangle (each quadrangle covering approximately 58 square miles). Factors that would inhibit or restrict mining of remaining coal resources were identified and applied to each coalbed. Computer graphic and resource calculation programs of the U.S. Geological Survey National Coal Resources Data System (NCRDS) were utilized to perform these studies. Presented here is a synopsis of the 1989 Wise quadrangle coal availability study to provide insight into this program.

The Wise 7.5-minute quadrangle is located in south central Wise County and northern Scott County in the southwestern Virginia coalfield (Figure 1.). The quadrangle is in the Cumberland Mountains section of the Appalachian Plateaus physiographic province and encompasses a portion of the east-west trending Powell Valley anticline in the southern half of the quadrangle. Topography in the region is characterized by dissected uplands with generally steep ridge slopes and v-shaped valleys (Eby, 1923). The maximum elevation within the quadrangle is approximately 4180 feet at High Knob, west of the Intermont Girl Scout Camp, near the crest of the Powell Valley anticline. The maximum topographic relief in the quadrangle is 2180 feet. However, the topographic relief is generally less than 890 feet in the northern half of the quadrangle, where most of the coal resources occur.

The available coal resources study undertaken for Wise quadrangle involved evaluating 18 economically significant Pennsylvanian-age coalbeds. These coalbeds are shown in relative stratigraphic position in Figure 2. All of the coals

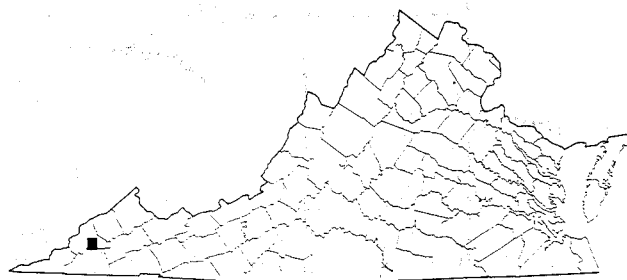


Figure 1. Location map of Wise 7.5-minute quadrangle, Wise County, Virginia.

studied are above drainage, with traceable outcrops. Only the more regionally persistent and correlative coalbeds exceeding 14 inches in thickness were studied. All 18 coalbeds are within a stratigraphic interval of approximately 3275 feet. The majority (78%) of the preserved coalbeds extend across only the northern half of the quadrangle because the principal coal-bearing rocks upwarped by the Powell Valley anticline are largely eroded in the southern half of the quadrangle. Therefore, the majority of the coalbeds southernmost outcrop lies along a nearly east-west line defined by the northern limb boundary of the anticline, essentially along the Guest River Valley midway in the quadrangle. Only the lowermost coalbeds (22%) are present south of this boundary. North of this boundary, near the western edge of the quadrangle, the north-south trending, nearly vertical Glamorgan fault has an apparent, small left-lateral strike-slip displacement with local variations of vertical displacement (Whitlock and others, 1988).

Outcrop maps of the coalbeds were prepared from the recently published geologic map of Wise quadrangle (Whitlock and others, 1988). Data for 234 coalbed locations were

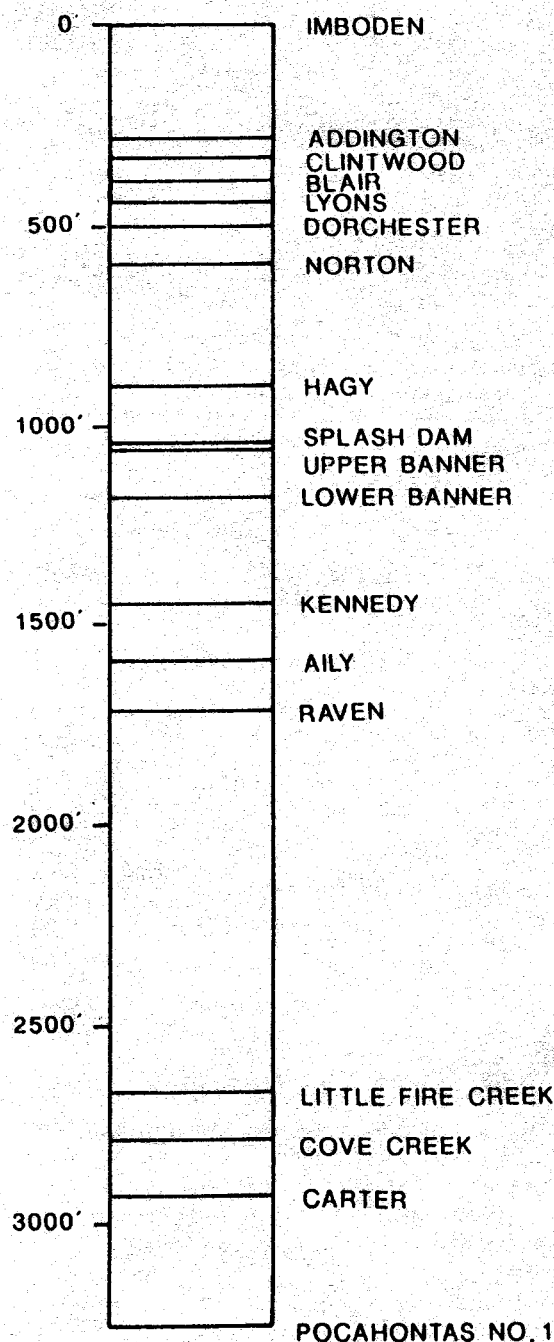


Figure 2. Coalbed columnar section showing coals for which resource calculations were made.

evaluated. In addition, 87 drill hole summaries were obtained from several coal companies. This data is not uniformly distributed within the quadrangle. However, the distribution of data is more uniform in the principal coal-bearing region north of Guest River. Mined areas were delineated from maps provided by the Virginia Division of Mines. Surface mines were identified from the most recent Wise 7.5-minute topographic map and the geologic map of Wise quadrangle (Whitlock and others, 1988). Mined areas for each coalbed

were superimposed on the corresponding coalbed outcrop map. The outcrops and the mined areas were then digitized. Detailed stratigraphic cross-sections were constructed from the data to assure accurate coalbed correlations within the quadrangle.

It should be noted that these coal availability studies are results of a cooperative program with the U.S. Geological Survey and the Virginia Division of Mineral Resources to provide a more realistic assessment of coal resources available for development within the state. Appreciation is expressed to the staff of the U.S. Geological Survey Branch of Coal Geology involved with the NCRDS program.

### RESTRICTIONS

Various restrictions affect both surface and deep mining operations. These restrictions are both land-use oriented and technologically oriented toward coal mining practices. Land-use restrictions primarily affect surface mining and deep mining with less than 200 feet overburden. Technologic restrictions generally affect deep mining practices and are based largely on mining technology, safety, and cost considerations. Existing oil and gas wells are factors common to both land-use and technologic restrictions applied to mining practices.

The Glamorgan fault in the Wise quadrangle does not appear to deter mining activities. Mine operations on both sides of the fault have proceeded to the truncation of the coalbed against the fault. Local dips of coalbeds along the fault, as well as along the northern limb of the Powell Valley anticline, are not great enough to hinder mining operations. Minor faulting associated with some coalbeds affects mine roof stability locally. However, these areas are mined with caution. Therefore, there were no restrictions to mining practices applied to this study based on these particular geologic factors. Other geologic factors of concern are geochemically oriented but there is insufficient data to identify such restricted areas at this time.

All overlap of two or more restrictions to mining was removed prior to calculation of the available coal resources.

### LAND-USE RESTRICTIONS

#### OIL AND GAS WELLS

There were 25 oil and gas wells in the Wise quadrangle at the time of the study. These wells were drilled between 1890 and 1988 and have depths ranging from 1407 feet to 8357 feet. As prescribed by the Mine Safety Laws of Virginia (45.1-92.1), mining is to be restricted around existing oil and gas wells. Therefore, a buffer zone having a radius of 200 feet was applied to each well location as an area of restriction to mining. It should be noted that mine operators can file petitions to mine nearer to, or through well locations. A State Mine Inspector may approve the exception.

#### CEMETERIES

Although there is no specific law prohibiting mining

through or beneath existing cemeteries, the Office of Surface Mining (OSM) requests mine operators filing for mining permits to provide a buffer around cemeteries. For this reason, a buffer zone 100 feet wide was applied to the digitized areas of existing cemeteries, thus defining a restricted area.

#### STREAMS

Areas immediately under or within 100 feet of major streams are considered as land-use restrictions primarily to avoid potential surface subsidence and the possible interruption of surface water flow. Wise quadrangle contains only one major stream, the Guest River, which flows along the aforementioned northern limb of the Powell Valley anticline. Where the flow appeared to be greater than 5 cubic feet per second, the area of the stream course including a 100-foot buffer on both sides was digitized and classified as a land-use restriction.

#### TOWNS

The presence of population centers restricts surface and near surface mining operations. This is principally due to inaccessibility for surface mining and the potential for induced surface subsidence from deep mining. As with major streams, OSM recommends that mining be restricted within town limits and boundaries when filing for mining permits. Municipal boundaries and rural community areas were outlined and digitized as land-use restrictions.

#### HIGHWAYS, PIPELINES, AND POWERLINES

There are no specific laws prohibiting mining through or under these structures in the State of Virginia. Surface mine operators tend not to disturb highways or pipelines and have mined between powerline poles. Operators mine beneath all these structures. Due to these practices, those structures listed above were not considered as viable land-use restrictions.

#### NATIONAL FORESTS

The Surface Mining Control and Reclamation Act of 1977 prohibits surface mining on National Forest lands, particularly within the eastern United States. For this reason, lands of the Jefferson National Forest in Wise quadrangle were considered as land-use restrictions. Deep mining is allowed beneath National Forest lands upon approval of a Federal Mineral Mining permit.

### TECHNOLOGIC RESTRICTIONS

#### OIL AND GAS WELLS

The factors mentioned above for land-use restrictions regarding mining near oil and gas wells are also considered for safe mining practices, and therefore apply to deep mining operations.

#### MINE BUFFERS

The Mine Safety and Health Administration (MSHA) requires for safety a buffer zone of unmined coal to be maintained around all mine workings. If active mining encounters

an existing mine, the older mine must be either ventilated, pumped if necessary, and/or sealed. For planning purposes, most operators maintain a 100 to 200-foot buffer zone around known mine workings. For this study, a 200-foot buffer zone was added to the area of all deep mine workings within this quadrangle for exclusion from mining as a technologic restriction.

#### INTERBURDEN

Interburden thickness between coalbeds may affect the mining of the overlying or underlying coalbeds by increasing mining hazards and the cost of mining. Although this interburden effect on mining is somewhat variable, a conservative 40-foot interburden restriction was applied as current mining practices experience little to no adverse effects with interburdens greater than this value, thus allowing both coalbeds to be mined. Therefore, in the case of two coalbeds which are less than 40 feet apart, a decision was made as to which coalbed would most likely be mined in preference to the other. That area of coal with less than 40 feet interburden was removed from the less desirable (thinner) coalbed on the premise that the mining of this coalbed would be restricted by the mining of the more desirable (thicker) coalbed.

#### MINING LESS THAN 40 FEET

Coalbeds that have been or are being mined, and are within 40 feet of another minable coalbed, affect the potential mining of the other coalbed by reducing the stability of the roof or floor of mines in the other coalbed. Therefore, the areas where mine workings are within 40 feet of another coalbed were considered to restrict the mining of the unmined portion of the other coalbed.

#### UNMINABLE THICKNESSES

Generally mine operators in Virginia consider that coals less than 40 inches thick are not economically feasible to deep mine if a shaft is necessary to access the coal. All the mines within Wise quadrangle have adit entrys directly into the coalbeds and some appear to support mining operations in coalbeds between 14 and 28 inches thick. However, coalbeds with overburden greater than 1000 feet thick are only being mined where they are more than 28 inches thick. It was therefore decided that any coalbed less than 28 inches thick with more than 1000 feet of overburden would currently be restricted from mining.

### RESOURCE CALCULATIONS

Total original, remaining, and available coal extent was determined for each coalbed. Respective coal resources for each of the above were calculated only for that portion of each coalbed with a thickness greater than 14 inches, as determined by thickness isopachs constructed for each coalbed. Categories used for each resource calculation (original, remaining, and available) are as follows:

- 14-28 inches thick and 0-200 feet overburden
- 14-28 inches thick and 200-1000 feet overburden
- 14-28 inches thick and greater than 1000 feet overburden

greater than 28 inches thick and 0-200 feet overburden  
 greater than 28 inches thick and 200-1000 feet overburden  
 greater than 28 inches thick and greater than 1000 feet overburden.

Strip mined areas were included in the categories with 0-200 feet overburden. Where present, the volume of coal affected by auger mining was added to the deep mine volume in the 0-200 feet overburden categories because of the many openings, the closeness of spacing and the length of boring within the coalbed. Deep mined areas, and strip mines where present, were removed from each original coal resource category resulting in the remaining coal resources for each coalbed. Where strip mining and deep mining with 0-200 feet overburden were present, the volume of coal removed by deep mining was first calculated. Remaining coal resources for each bed were then calculated. The volumes of mined out coal for categories having more than 200 feet of overburden were then determined by subtraction of remaining from original resources. With the deep mine coal volumes in the 0 to 200-foot overburden category previously calculated, the difference between the deep mined and remaining resources then defined the strip mine volumes where applicable.

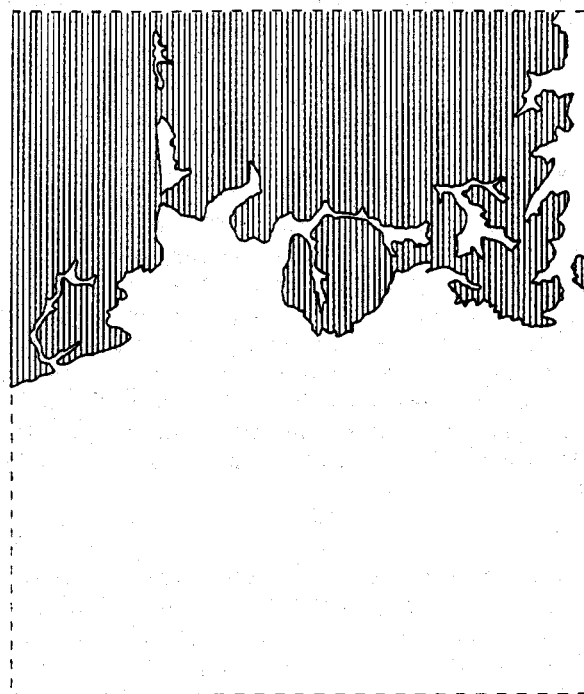
Three points must be noted in regards to the amount of mined-out coal. First, coal less than 14 inches thick has been strip mined in small areas. These small volumes of coal are not considered in the resource calculations. Second, there are small volumes of coal with overburden greater than 200 feet that have been strip mined. These values are incorporated within the deep mined volumes in the 200 to 1000-foot overburden category. Third, there is no area overlap of strip mining and deep mining in the 0-200 feet of overburden category.

Restrictions to mining operations were identified and the volumes of coal affected by each restriction were calculated. Overlap of successive restrictions were removed thus defining the available coal resources for each coalbed. The available resources, per category, were then calculated for each coalbed.

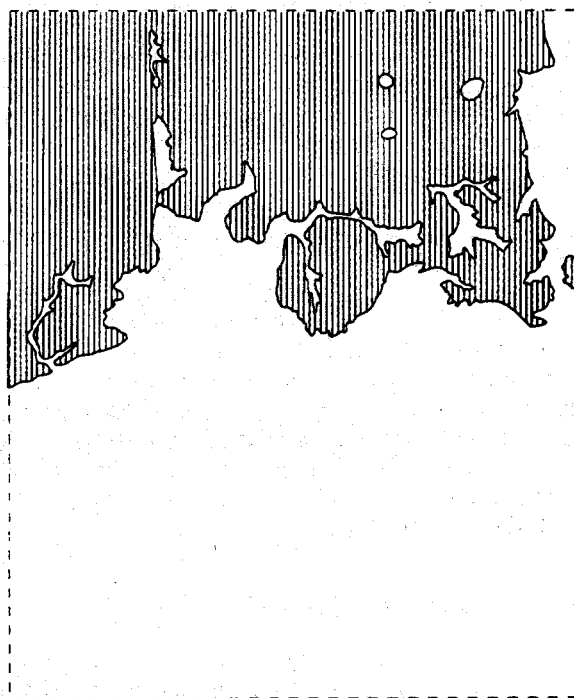
For the study, each coalbed's mapped resources are depicted within the quadrangle. Additionally, an illustrative pie chart showing the coal mined, the restricted coal, and the coal available for mining relative to each coalbed's original resources, is also presented per coalbed (see example in Figure 3F). The final compilations for the Norton coalbed are included as an example of the results of the many procedures applied to data for each coalbed in the study (Figure 3).

## RESULTS

The results of this study indicate that there are 520.3 million short tons of coal resources available for mining within Wise quadrangle. This is 65% of the calculated original coal resources and 67% of the calculated remaining coal resources for eighteen minable coalbeds in the quad-

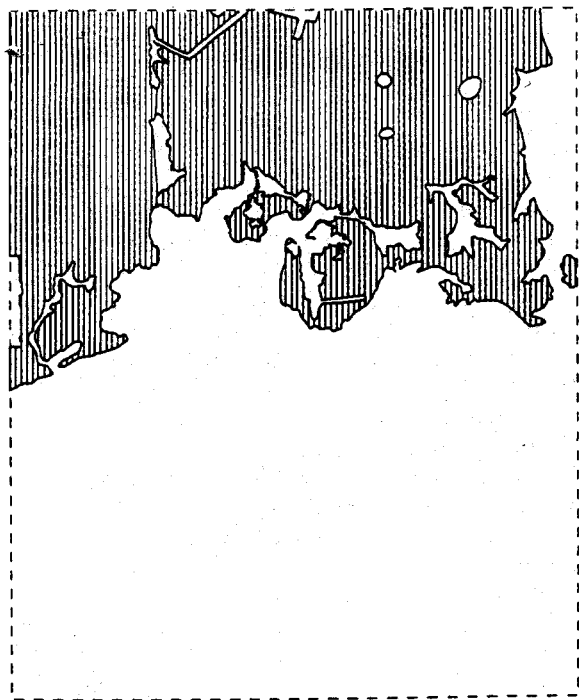


A

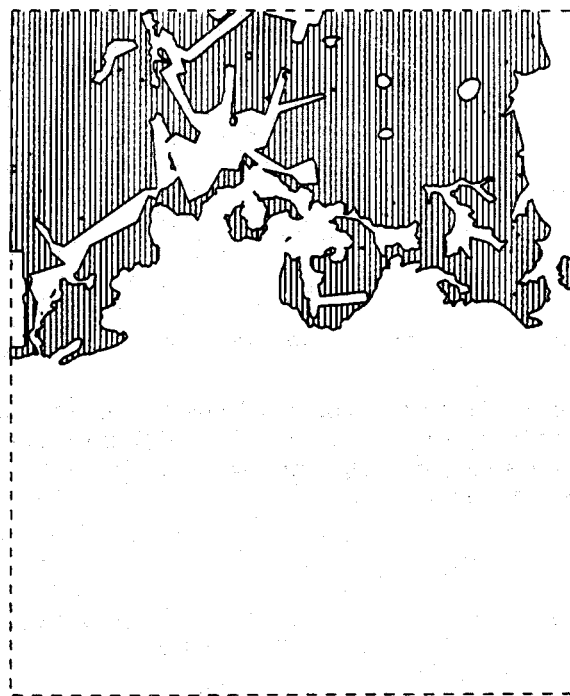


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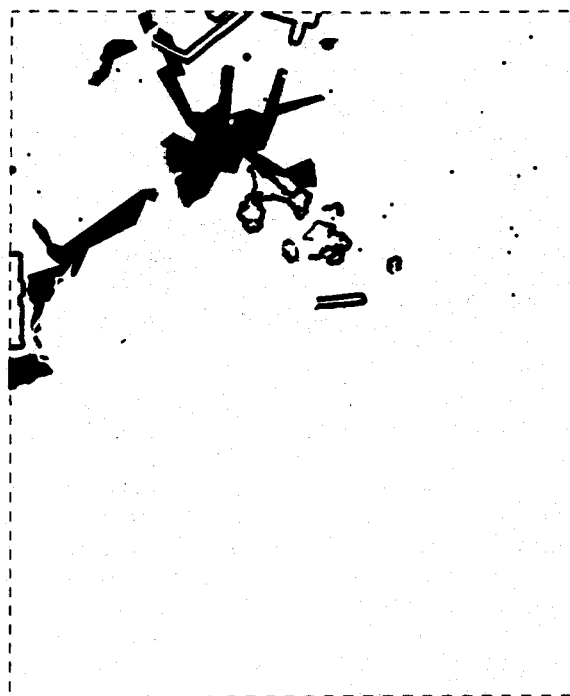
Figure 3. Coal availability study results for the Norton coalbed; original extent (A), original resources (B), remaining resources (C), restrictions (D), available resources (E), and pie chart showing percentages of original resources (F).



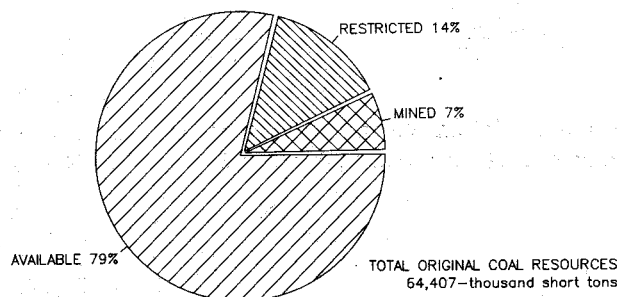
C



E



D



F

Figure 3. Continued.

range (Figure 4). Technologic restrictions accounted for nearly 90% of the total restricted coal in Wise quadrangle. The restriction of having a 28-inch minimum thickness when the overburden thickness is more than 1000 feet accounted for 69% of the coal excluded by technologic restrictions (Figure 5). Local population centers accounted for 78% of the coal excluded by land-use restrictions (Figure 5). Original, remaining, and available coal resources for the individual coalbeds are shown in Figure 6. As noted, for the quadrangle and for each individual coalbed, applied restrictions to mining can significantly alter the remaining coal resources to provide a more realistic estimate of available coal resources.

### COMPARISON TO PREVIOUS STUDIES

Brown and others (1952) presented an estimation of remaining coal resources for all of Wise County, thus providing a tenuous comparison with the present single quadrangle

Figure 3. Continued.

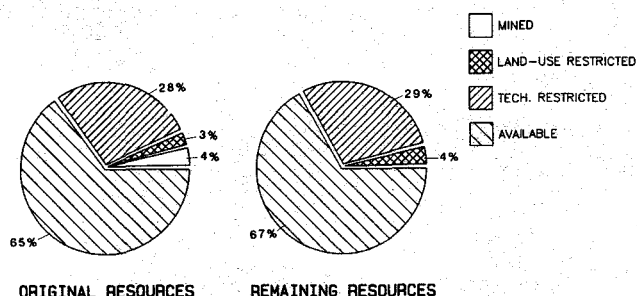


Figure 4. Comparison between the total original and total remaining resources of all coalbeds studied in Wise quadrangle showing percentages affected by land-use and technologic restrictions.

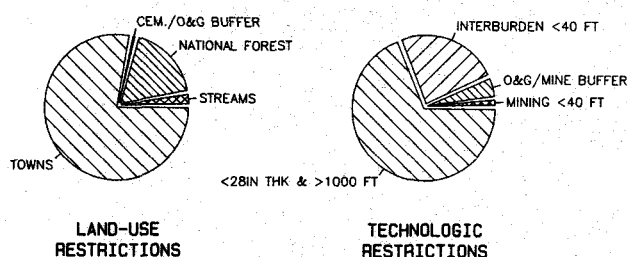


Figure 5. Pie chart comparison of total land-use and technologic restrictions for all coalbeds within Wise quadrangle.

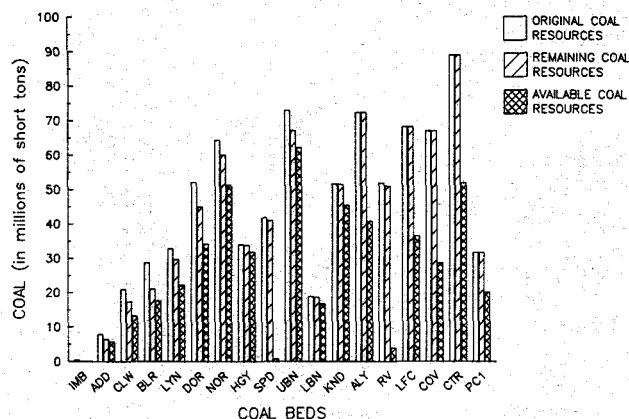


Figure 6. Total amounts of original, remaining, and available resources for each coalbed studied in Wise quadrangle; Imboden (IMB), Addington (ADD), Clintwood (CLW), Blair (BLR), Lyons (LYN), Dorchester (DOR), Norton (NOR), Hagy (HGY), Splash Dam (SPD), Upper Banner (UBN), Lower Banner (LBN), Kennedy (KND), Aily (ALY), Raven (RV), Little Fire Creek (LFC), Cove Creek (COV), Carter (CTR), and Pocahontas No. 1 (PC1).

study of a portion of Wise County. Categories of coal thickness, overburden thickness, and occurrence probability applied by Brown and others (1952) are essentially the same as those adopted for the current NCRDS program. Therefore,

a general comparison can be made of the remaining coal resources calculated for both studies. Although only remaining coal resources are comparable, the current study further presents a more realistic estimate of available coal resources. Besides the major difference in the size of the areas studied, any comparison of the two studies should also be prefaced by noting the following points concerning the present study:

1) Considerably more subsurface data was incorporated into the present study than was available to previous workers.

2) The addition of the subsurface data, coupled with recent detailed field mapping, permitted a better understanding of coalbed correlations.

3) Recently created regulatory agencies provided data which better delineated mined out areas.

A detailed comparison between this study and Brown and others (1952) of remaining resources for 18 coalbeds is presented in Table 1. Four significant results have been derived from the comparison.

1) The present study indicates existing remaining resources for four coalbeds (22%) for which Brown and others (1952) had calculated no remaining resources within the entire county. These four coalbeds total more than 261 million short tons of additional remaining coal resources (of which 57% qualify as being available resources).

2) The present study found that ten coalbeds (56%) contained between .1 and 71 percent of the remaining resources for each coalbed as calculated by Brown and others (1952) (Table 1). This result is to be expected as these coalbeds occur only in the northern half of the quadrangle, which is only a small portion of Wise County.

3) In addition to the first result, the remaining resources calculated for four other coalbeds (Addington, Hagy, Splash Dam, and Cove Creek) in Wise quadrangle were larger by 2.1 to 66.8 million short tons than the remaining resources for the same four coalbeds as calculated by Brown and others (1952) for the entire county. These four coalbeds now account for a total of 123.3 million short tons of additional remaining resources than earlier indicated. Furthermore, three of these four coalbeds (Addington, Hagy, and Cove Creek) contain more available resources than Brown and others (1952) indicated as remaining resources for these coalbeds in the entire county.

4) The present study indicates that there is a total of 715.8 million short tons remaining coal resources less than that indicated for the same 18 coalbeds by Brown and others (1952). This result is to be expected as the present study covers only a portion of the entire county. However, it is also noteworthy that the present study reveals current remaining resources for this portion of the county to be nearly half the total remaining resources for the entire county as presented by Brown and others (1952).

In summary, current results show available coal resources of Wise quadrangle to be 67% of the remaining coal resources. Land-use and technologic restrictions preclude the mining of 33% of the remaining coal resources in this quadrangle. Restrictions exerted the greatest effect on the Splash Dam coalbed by "carving-out" 98% of that coalbed's remaining resources.



Table 1. Comparison of the remaining resources for eighteen coalbeds studied; values are in millions of short tons.

	WISE COUNTY R.R.	WISE QUADRANGLE R.R.	A.R.
Imboden	186.4	0.2	0.2
Addington	4.4	6.5	5.8
Clintwood	167.4	17.4	13.2
Blair	157.0	21.1	17.7
Lyons	132.3	29.6	22.2
Dorchester	194.0	44.9	34.2
Norton	170.2	60.1	51.3
Hagy	9.1	33.9	31.9
Splash Dam	11.4	41.0	0.8
Upper Banner	94.1	67.1	62.2
Lower Banner	116.8	18.7	16.8
Kennedy	112.9	51.5	45.4
Aily	NC	72.4	40.8
Raven	130.8	51.0	40.4
Little Fire Creek	NC	68.2	36.5
Cove Creek	0.2	67.0	28.7
Carter	NC	88.9	52.0
Pocahontas No. 1	NC	31.7	20.2
<b>TOTAL</b>	<b>1487.0</b>	<b>771.2</b>	<b>520.3</b>

R.R. = remaining resources.

A.R. = available resources.

NC = not calculated.

## REFERENCES CITED

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Whitlock, W.W., Lovett, J.A., and Diffenbach, R.N., 1988, Geology of the Wise quadrangle and the coal-bearing portion of the Fort Blackmore quadrangle, Virginia: Virginia Division of Mineral Resources Publication 80, 1 map.

## POTENTIAL GEOLOGIC HAZARDS

### SINKHOLE ASSESSMENT

Sinkholes are not very compatible with many of man's land-use activities. They are most commonly associated with caves, pinnacled bedrock, and subterranean drainage in the negative relief topography, termed karst terrain, formed by the dissolution of carbonate or other soluble rock types. Sinkholes are closed depressions that generally form by the subsidence or collapse of soil or rock into a subsurface void.

Although sinkholes have been observed throughout the Commonwealth, they are most plentiful in the Valley and Ridge physiographic province in parts of 27 counties west of the Blue Ridge Mountains. Virtually all of the thick sequences of various carbonate (limestone and dolomite) rock types exposed to weathering in the

Valley and Ridge province have undergone some degree of karstification. It is probably reasonable to assume that the greater the density of sinkholes and caves, the greater the potential for sinkhole associated problems: sinkhole flooding, subsidence, and groundwater pollution problems.

Flooding is not a major hazard in Virginia karst. Sinkholes are natural input points for surface water to enter into the groundwater aquifer. Some of man's landuse and development activities may trigger sinkhole problems. The restriction of sinkhole drains as a result of poor siltation control during construction and the greater volume of runoff from manmade surfaces such as pavement, roofs, and poor drainage designs contribute to sinkhole flooding problems. In extreme cases sinkhole infiltration can overwhelm the capacity of the subsurface conduits so that sinkhole drains are back-flooded much as a storm sewer can backup and discharge storm water out of manholes and box culverts. Buildings and most other manmade structures should not be constructed in or over sinkholes because of the potential for flooding and subsidence hazards. Subsidence is commonly triggered by hydrological changes in drainage or water table fluctuations, either natural or man induced. Sinkholes are examples of differential subsidence in an unstable terrain. The third and foremost problem associated with sinkholes concerns groundwater pollution. Liquid wastes or leachates from solid wastes dumped or draining into sinkholes can enter the groundwater system through underground routes or conduits that drain sinkholes. The use of sinkholes as drainage outfalls for storm sewers and other piped effluents can lead to two types of problems: subsidence and groundwater pollution. The altered hydrological input may promote active subsidence in the sinkhole or the formation of new sinkholes nearby. Leaks and spills of fuels, oils, or other chemicals on roads or other paved areas that drain into sinkholes can contaminate groundwater.

In assessing the presence of sinkholes, the most effective technique generally is a detailed on-site canvas of the entire property; however, sinkholes may have been filled by previous owners or may not be visible through dense vegetation between late spring and early fall. Aerial photographs taken from late fall to early spring and topographic maps are useful for preliminary assessment. Sinkhole and cave locations have been mapped on a regional scale of 1:250,000 for planning purposes for two thirds of the Valley and Ridge province of Virginia. The sinkholes were located by stereoscopic examination of the same aerial photography that is used to photorevise 1:24,000-scale topographic maps. A comparison of the stereoscopic method and 1:24,000-scale topographic maps reveals that, on the average, only 25 percent of the sinkholes found by stereoscopic examination of the low altitude aerial photography are indicated on topographic maps. The sinkholes depicted on the topographic maps are determined by the contour interval of each map and the elevation, depth, and size of the sinkholes. Topographic maps with a 20-foot contour interval depict approximately 31 percent of the photo-identifiable sinkholes, while maps with a 40-foot contour interval depict approximately 15 percent of the photo-identifiable sinkholes. A comparison of different topographic contour intervals indicates a topographic map with a 40-foot contour interval depicts approximately 58 percent of the sinkholes depicted on a 20-foot contour interval topographic map.

The real question is how many sinkholes are in a given area? As was noted above, the definitive answer to this question can be answered best by detailed on-site evaluation. To date there has not been a comparative study of actual sinkholes and the stereoscopic method over individual topographic areas. A crude estimate indicates that the stereoscopic method locates between 18 and 80 percent of the total sinkholes and topographic maps depict between only five and 20 percent of total sinkholes in Virginia.

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